The Urban Form Standard ***A System of Land Subdivision***

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"A complex system, contrary to what people believe, does not require complicated systems and regulations and intricate policies. The simpler, the better. Complications lead to multiplicative chains of unanticipated effects. Because of opacity, an intervention leads to unforeseen consequences, followed by apologies about the 'unforeseen' aspect of the consequences, then to another intervention to correct the secondary effects, leading to an explosive series of branching 'unforeseen' responses, each one worse than the preceding one." —Nassim Taleb, Antifragile

"Streets and their sidewalks, the main public places of a city, are its most vital organs. Think of a city and what comes to mind? Its streets. If a city's streets look interesting, the city looks interesting; if they look dull, the city looks dull." —Jane Jacobs, The Death and Life of Great American Cities

"The most meaningful permanences are those provided by the street and the plan." —Aldo Rossi, The Architecture of the City

"A skyscraper in a large city is a significantly more complex object than a modest family dwelling in a small town, but the underlying principles of construction and design, including questions of mechanics, energy and information distribution, the size of electrical outlets, water faucets, telephones, laptops, doors, et cetera, all remain approximately the same independent of the size of the building. These basic building blocks do not significantly change when scaling up from my house to the Empire State Building; they are shared by all of us." —Geoffrey West, Scale

"Metiendo Vivendum" (By measure we live). —Personal motto of English architect Edwin Lutyens

About the Author
Paul Knight, AICP, is an architectural and urban designer at Historical Concepts, an architecture and planning firm based in Atlanta, Georgia. Knight also serves as the executive director of the Doug Allen Institute (see information below) where he conducts research linking urban form to health, safety, and welfare. He received M.Arch and MCRP degrees from Georgia Tech in 2011.

The Douglas C. Allen Institute for the Study of Cities
The Doug Allen Institute is a non-profit 501(c)(3) organization promoting the principles of urban design and lessons of history to students and professionals. With a focus on public education, the Institute seeks to make our increasingly urbanized world a better place to live.
To learn more or to donate, please visit *www.DougAllenInstitute.org*.

Doug Allen
Douglas C. Allen, FASLA, beloved professor and visionary landscape architect, died on October 26, 2014, from brain cancer. Doug graduated in 1970 from the University of Georgia with a Bachelor of Landscape Architecture and from Harvard University in 1976 with a Master of Landscape Architecture. In 1977, he began a 37-year teaching career in the College of Architecture at Georgia Tech, except for the 1987-1988 year as visiting professor of landscape architecture at Harvard University.
Doug made seminal contributions to the field of landscape architecture, particularly to the study of cities and the urban landscape. He published, served on juries, and lectured widely at universities all over the United States. He served for several years on the editorial board of Places Journal, co-founded Georgia Tech's study abroad program in Italy, was honored by election to the Council of Fellows of the American Society of Landscape Architects (FASLA), and was awarded the ANAK Award in 2006 which is bestowed annually by a Georgia Tech secret society to a single professor for contributions to the students of the Institute.
Perhaps Doug's greatest influence was through his legendary course *The History of Urban Form* which was taught annually at Georgia Tech. As a testament to his intellect and engaging teaching style, one year his course was voted by students as the most popular elective on the entire Georgia Tech campus.

Preface

Preface for Version 2.0

The latest version of this working paper is substantially different from the first. In the first version, we expanded our design logic and dimensional analysis up to the scale of a country because we received funding to explore that arena. You can still view that "version 1.5" paper here (and read its original preface below, most of which is still relevant).

For this latest "version 2.0", we are removing the national planning discussions and instead focusing on the **neighborhood** and **city** scales of development. Why? A few reasons:

1. The neighborhood is an ideal "unit" of development. Whether one is working with a single lot or planning citywide infrastructure, the neighborhood unit should act as a benchmark or reference. *"How is this lot situated within its neighborhood?"* and *"Should we expand the subway system?"*: both of these questions depend on the neighborhood scale.
2. The neighborhood is also what we generally use as the frame in our minds when we think of where we live or where we visit. For example, I walk my dog around "the Lower East Side" not around "Manhattan". While I might tell someone I'm taking a trip to "Paris", I'm likely only experiencing the city one arrondissement at a time.
3. The majority of the things we build are relatively small: things like skyscrapers, houses, bus stops, football fields, blocks, lots, and streets. These "building blocks" iterate and scale up in aggregate to form a city. The study of architecture, urban design, urbanism, and city planning largely falls in this domain.

Now onto the fun part! -> *The Importance of Streets*

Paul Knight, AICP
May 12, 2023

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Preface for Versions 1.0 through 1.5

Urban Form Standard, v1.5 (pdf)

Perkins+Will, an international architecture and planning firm, received the commission to develop the Fourth Master Plan for the country of Kuwait. Not county—*country*. Let's think about that.

I recall watching the renovations of some existing water and sewer lines along a short stretch of Northside Drive here in Atlanta. It occurred in slow motion over a period of perhaps two years. Every day I would drive by, catching a glimpse of each individual frame of the real-life cartoon. There was the plan, then the concerned neighbors, then the replanning, site prep, construction with half a dozen workers watching one poor soul dig a hole, and then waiting another series of months to paint the road stripes, and finally, finally, the removal of the traffic cones and opening of the lanes. Meanwhile, elsewhere in the world, in China, India, the Middle East, dozens of cities to house millions of people had been built from scratch.

Worldwide, urbanization is happening at speeds and scales never seen until now, taking place in hastily-built megacities. The first time I saw this myself was on a trip to India a few years ago. Surrounding the highway were concentrations of new growth, forests of skyscrapers and tower cranes sprouting from the earth. I can only imagine the level of coordination for such things, picturing an army of professionals out there planning the various infrastructures, be it economic, transportation, political, legal, programmatic, environmental, sanitation, utilities, etc. But peel all of that back and consider the context of *urban form*, the underlying structure of all cities, the boundaries delineating spaces public and private, streets and blocks, mine and yours. What is happening in that domain?

Many architects and planners have created their own versions of idealized cities. Le Corbusier had his *Plan Voisin*; Frank Lloyd Wright, *Broadacre*; Daniel Burnham, *Chicago*; Hippodamus, *Miletus*; Haussmann, *Paris*; Niemeyer, *Brasilia*. But those are mere *cities*; let's take it a couple magnitudes further to *countries*. How does one physically plan the urban form of an entire country? How does one account for all the components of the built environment within a single system, including what is known, what is unknown, and the unknown unknowns, and address the various scales of the human experience, from country-wide mega-regions harboring millions to single-person reading nooks? That's the question we want to answer, or at the very least explore.

David Green, Perkins+Will's Global Urban Design Leader, reached out to the Doug Allen Institute to do that exploration. I am excited to make the first set of these working papers available. The papers are a continuation of Doug Allen's research; they make some improvements on the American Land Ordinance of 1785, apply those lessons and principles to international lands, make a strong suggestion in regards to number theory, and extend the study into the smaller scales of design including neighborhoods, blocks, lots, buildings, and even rooms, furniture, and objects. It is by no means presented here as a refined, finished product. As a working paper, these are thoughts and ideas that are still being developed, reconsidered, critiqued, pushed, and pulled. We welcome any comments you may have.

Paul Knight, AICP
September 6, 2018

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Streets

Permanence

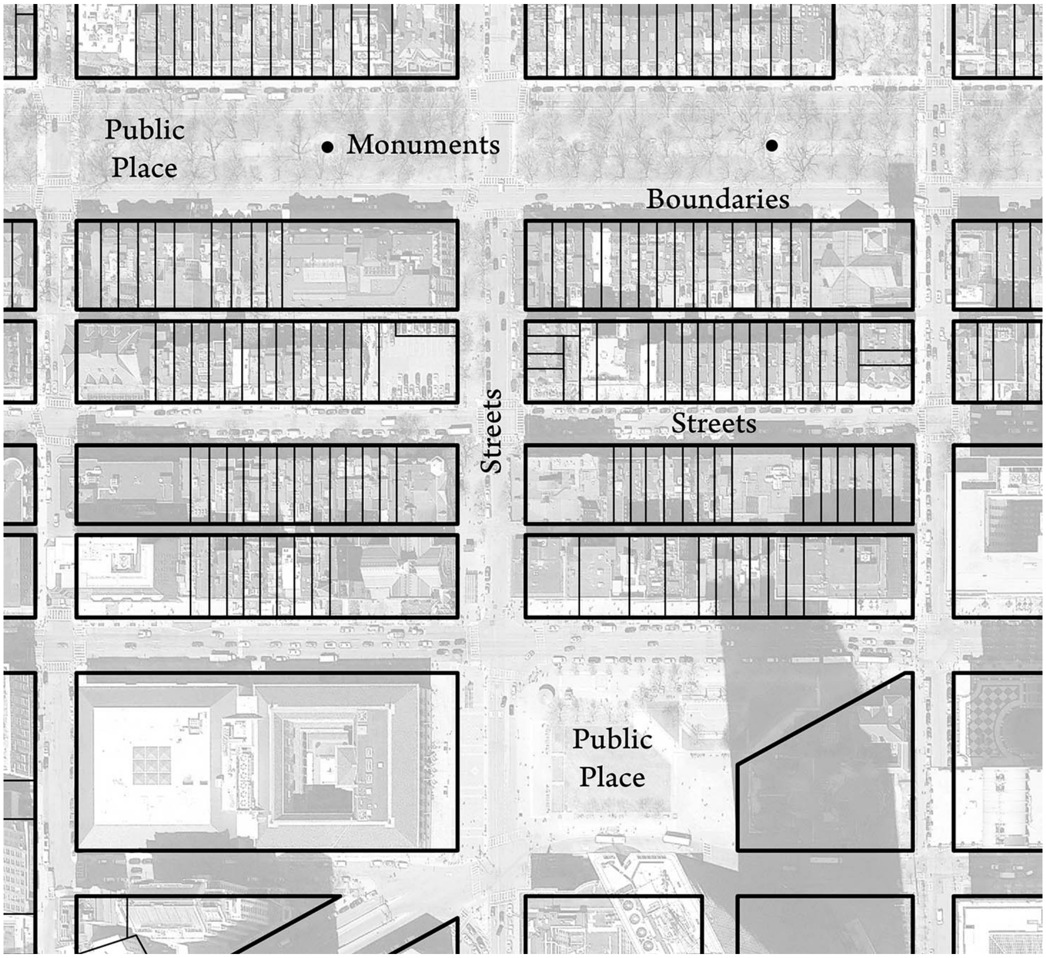
What are cities made of? Think on this for a second and picture yourself walking or driving around. What do you see? Cars, dumpsters, people, trees, signs, sidewalks, ice-cream shops, shoe stores, hospitals, schools, libraries, skyscrapers, houses, apartments, etc. Cities are mankind's largest built work. Consider that each of the components just mentioned experience some level of change, at some rate, resulting in a life expectancy[1]. The average big-box retail building, for example, is built to last only 10, 15, or 20 years. Interestingly, humans, street trees, and the average building[2] share comparable life expectancies of roughly 80 years. But what is the element of the city that lasts the longest? The street.

CITY COMPONENT	LIFE EXPECTANCY (YEARS)
Car	20
Dumpster	20
Building (Big-Box Retail)	20
Street Tree	80
People	80
Building (Average)	80
Building (House)	150
Street Rights-of-Way	1,000s

Streets (i.e., the boundary lines, rights-of-way) can survive on the order of thousands of years. An example of this is illustrated in Imola, Italy. Imola was founded by the ancient Romans about 2,000 years ago. When they subdivided their territory, they used a unit called a *heredium* which is 240 feet on a side. The word heredium shares a similar root to the English word *hereditary*. The idea was that a family would continue to pass on and inherit these heredia over time. Now imagine this taking place over a 2,000 year period, with the apex of the Roman Empire and then its subsequent decline, when everyone retreated behind the walls of their medieval cities, and then reemerged during the Renaissance, and then sparked the industrial revolution, and then had a couple of World Wars, and now everyone is walking around with iPhones. Even under the pressure of immense change experienced over that span of two thousand years, those heredia are still guiding the growth of Imola today.

The boundary lines that were established by the ancient Romans two thousand years ago have subsequently been translated into farming lots, fences, building walls, streets[3].

Streets, then, form part of the "constitutional order" of cities: together with boundary lines, public places (including parks and buildings), and monuments, they are a part of the permanent framework of urbanism. The remainder, the "representational order", makes up the stuff we see day to day: cars, people, and private buildings, etc. These elements animate the constitutional order and give it meaning, but they are fleeting relative to the permanency of the constitutional order.



Resilience

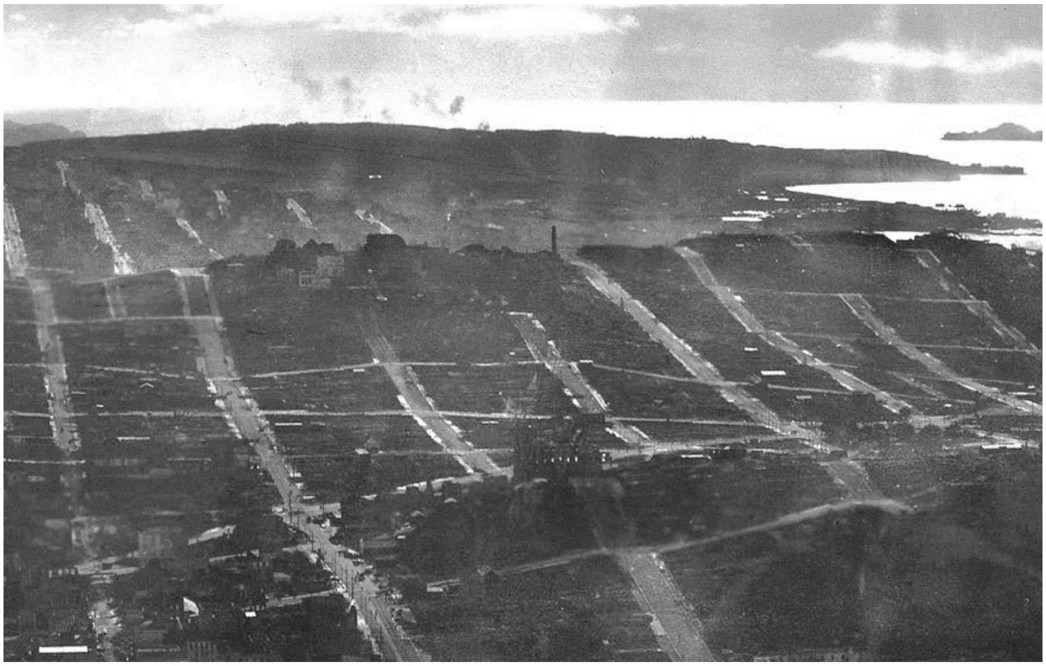
How do streets survive such long time scales? Where do they get their resiliency?

First, public streets are collectively owned. Each member of the public has a stake in its streets. It's relatively easy for one person to coerce a few people into doing something, but it's a lot harder for one person to coerce a few thousand or million people. A street cannot simply be moved from here to there without having to get potentially millions of people to buy into such a move. Additionally, the legal network that makes up the foundation of property ownership is a function of the location of streets. Where does a setback proceed from? The street. How does one enter their house? From the street. Streets are collectively owned and through the nature of the resultant property ownership become locked into place.

Second, streets are simply inherited assets. They are handed down from generation to generation. They are excellent receptors of investments made over time: one could start with a rutted-out dirt road, and then add some gravel, and then twenty years later add some asphalt, and twenty years later add some sidewalks, and then street lamps and street trees, and so on. As a public asset, they can be improved upon over many generations.

It is because of these two reasons that streets have survived incredible catastrophes through history. For example, the Great Fire in London in 1666 completely destroyed the city. Christopher Wren, one of the greatest architects of all time, tried to take advantage of the situation, seeing it as an opportunity to introduce new avenues (in the same fashion as Rome at the time) to London's dense, cranky street network. But because of the legal ownership patterns, the city's urban form largely reemerged from the ashes as it was before the fire. There was an urgency to rebuild, and that urgency outweighed the complexities of reconfiguring property lines.

In San Francisco in 1906, a catastrophic earthquake was followed by an even more catastrophic fire that ultimately leveled the entire city. The scenes of the destruction are striking, presenting a wasted landscape denuded of life. Similar to the case of London, Daniel Burnham (an influential American architect and planner) had spent the previous year before the earthquake reimagining the city's urban form. As a prelude to the 1909 Plan of Chicago, Burnham's plan for San Francisco had envisioned new avenues and thoroughfares, civic centers, and parks. Burnham delivered the plan to the city only a few days before the earthquake hit. And one would have thought the fire presented an incredible opportunity to implement the plan. However, similar to London, the grid of San Francisco resisted both fire and planner. San Francisco's urban form today is largely unaltered from its pre-1906 configuration.



Benefits

What do streets do for a city? What do they do for us?

In today's auto-oriented landscape, the most obvious thing streets do is connect people. Whether one lives in Atlanta, Agra, Paris, or Kuwait City, streets are the medium for getting around. They are driven on, biked on, and walked on. They get people and goods from point 'A' to point 'B'.

But they require much more appreciation than this. **Streets are not just for transportation. Just as importantly (if not more important), they provide access to property and they create frontage.** When someone goes to Paris and marvels at the city's monuments and architecture, they are seeing Paris primarily through its streets. The face of Paris is made up of the buildings that front the street, it is how Paris presents itself to the world. The lesson here is that the more streets a city has, the more street frontage it has, which means more front doors, more front yards, and more storefronts. More streets means more opportunities to open up a city to development, to produce these vibrant neighborhoods common in the great cities of the world.

Streets also help to subdivide land into developable and accessible units. There are some dimensions of streets that do this better than others. For example, take a block that happens to be 280 feet by 520 feet on a side. In Chicago, a block of that size accommodates condo buildings, and townhouses, and some bungalows. In Amsterdam, the exact same block accommodates townhouses and a palace. In Buenos Ares, the exact same block accommodates apartments and a market. That block could also be used to accommodate a grocery store and its parking. Or a Super Walmart. How can the exact same block accommodate all these things, all these different cultures, different languages, different building types, different land uses? This kind of flexibility is an amazing characteristic of good urban form, and it is one that is measurable and useable. As was already discussed earlier in the *Introduction*, the vast majority of what is built in the world—houses, shops, skyscrapers—are all based on the same dimensional DNA.

Additionally, **streets can contain public utilities.** As public spaces, this makes sense. David McCauley, author and illustrator, developed a wonderful book called *Underground* with beautiful drawings where he peels back the asphalt of New York streets to reveal what happens underneath. You would be amazed at what all we have shoved underneath our streets.

Finally, **streets are a city's largest public space.** Portland, Oregon, for example, has small blocks, 200 feet on a side. With typical right-of-way widths of 60 feet, the percentage of land in Portland that is allocated over to streets is 40%. That's almost half, by the way.

Over time and around the world, there have been numerous planners who have recognized the street's critical nature in cities. **Edward Basset**, one of the founding fathers of American planning and author of the 1916 Zoning Resolution in New York, said:

> *A civilized community needs streets for sewers, water supply, gas and electricity. This relates to the public health and comfort. It needs streets for water for fire protection and the movement of fire apparatus. This relates to public safety. It needs streets for foot and wheel traffic. This relates to all police power fundamentals.*

Frederick Law Olmsted, celebrated American landscape architect:

> *The street plan has always been regarded as the foundation of all city planning.*[4]

Otto Wagner in Vienna, one of the greatest architects in history:

> *Streets and squares demand the greatest care and attention in the planning of a city. They need to be discussed first.*[5]

And **Doug Allen**, one of the greatest visionaries in planning since Kevin Lynch:

> *Streets are the primary structural unit of the city.*[6]

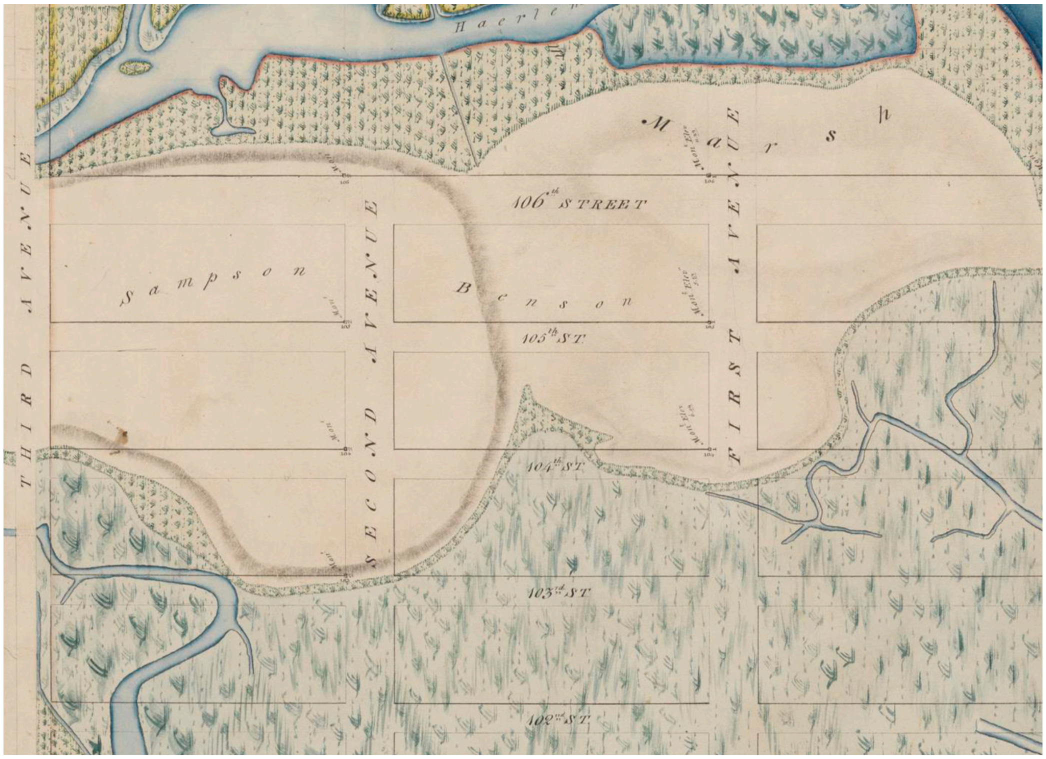
We find ourselves today, however, in a situation where city planners have either forgotten, chosen to forget, or never even had a chance to learn these insights. Because of this, **many of the streets built since the middle of the 20th century were put in place specifically for the movement of traffic and excluded all the other important functions and qualities of streets just mentioned. It is no wonder that the places that have been built around these one-dimensional, single-use "traffic sewers" are equally as one dimensional and single use. The character of the street directly affects the character of a place.** We will explore the repercussions of this and provide a fuller history in a subsequent chapter titled *The Enabling Acts*, but for now we will focus on the most important planning device ever conceived, one that has been largely lost for 100 years but holds the key, we believe, to building cities that are more walkable, sustainable, and enjoyable: *the master street plan*.

Master Street Plans

What is a Master Street Plan?

A master street plan is a plat that depicts both current and, most importantly, *all future streets within an entire jurisdiction*. That is to be taken literally: within a jurisdiction, within an entire town or city, every single street that is ever going to be built is planned for at once. Think of it as a pre-approved subdivision plat; it is a drawing of a city's desired urban form.

This may sound far fetched, but history provides us with numerous examples of its successful use. One of the most famous and well-documented[7] examples of a master street plan is the 1811 map of Manhattan. At that time, a group of Commissioners, seeing substantial growth looming in New York's future, sought to provide a physical framework for that growth, one that addressed not necessarily the "what" but the "where" of city planning. They didn't know what was coming, but they created a logical pattern of subdivision to give all the unknowns a place to go. Over the following decade after the street plan was adopted, the streets indicated on Manhattan's 1811 map were surveyed in the field. Large stone monuments were used to mark the corners of future blocks with the future right-of-ways offset from them. By physically surveying the streets, the plan was taken from paper into reality and could thus be protected from physical infringement (whether unintentional trespass or otherwise). A master street plan is no good unless it is on a plat that defines precisely where the boundary lines are going to be.



In the Commissioners' report that accompanied the plan, they projected it would be at least "a thousand years" before the plan was physically realized in its entirety.[8] The actual streets of Manhattan, however, were largely built out over a single century. But consider the amount of change that Manhattan experienced over that time: exponential population growth, political regimes, building technologies, etc. As development occurred, as developers saw individual needs for housing and schools and shops, the streets were simply constructed per the plan, piece by piece. Remarkably, even with Manhattan's rapid and history-making changes, this adherence to the street plan lasted well into the 20th century culminating in its eventual and substantial completion.

A master street plan is a simple line drawing, showing the boundary lines that indicate private property and public property. As we have seen, all of urban design can be reduced to a delineation between public and private property. A master street plan reflects this clearly and succinctly.

A street indicated on a master street plan appears simply as two parallel lines which are separated by some scaled distance. A series of 60-foot wide rights-of-way may appear identical on a master street plan, but in reality they may take on dramatically different characters: one my be a rutted-out dirt road, while another my be paved with sidewalks and lined with skyscrapers. The boundary lines are indistinguishable in plan view; they are essentially the same street. But streets grow up differently under different circumstances even if they share the same dimensional DNA. Given enough people, enough building, enough time, and the right dimensions, a rutted-out dirt road can grow into an urban thoroughfare.

We provide two analogies here that may help to further emphasize the utility of a master street plan:

A master street plan is like a jigsaw puzzle: When you buy a puzzle it comes in a box, and on the cover of that box is a picture. That picture is your goal. It guides your placement of the pieces. So regardless of how long it takes you, regardless of how many people are involved, eventually you will reach your goal. And a master street plan operates in the exact same way. Regardless of whether it takes ten years, or a hundred years, or a thousand years, whether it takes ten developers or a thousand developers, as long as there is an established reference, the city will reach its desired urban form. Thus, a city without a master street plan is like a puzzle without a picture: there are no references for where the pieces should go. But unlike puzzle pieces, once the components of cities are placed they are incredibly hard to pick up and move if necessary, making master street plans all the more useful.

A master street plan is like a blueprint for a city: In architecture, the construction drawings of a house reveal the locations of where each wall should be built. A builder adheres to the plan, constructing the walls where indicated. The result, after a while, is a house that reflects the original intention, the original plan.

It is a similar exercise for a city: a master street plan shows where each street should be built. Developers adhere to the plan, constructing new streets where indicated. The result, after years or decades, is a city that reflects the original intention, the original plan.

The building of a house is not left to mere chance, nor should a city. The application of a master street plan is the most direct way to achieve a desired urban form and thus ensure that a certain level of walkability, adaptability, efficiency, and economy are built in.

While a house is built at once, that does not mean it cannot change: rooms can be painted various colors, pictures can be hung from the walls, inhabitants can move in and move out, even additions and renovations are an option. It is similar with a city. Even though a physical street plan becomes locked into place, all the life that happens within that framework of streets is allowed to change and adapt as it naturally needs to. Streets are there only to provide structure, not content.

Planning in the Right Order: Subdivision and Zoning

City planning is a complex process, especially in our modern times. However, it can largely be reduced into two primary domains: **zoning** (the regulation of private property) and **subdivision** (the order of public property). These two domains compete for attention, but over the last century zoning has come to dominate the process.[9] We will show here how putting zoning first is detrimental to the more permanent and important patterns of subdivision.

In many jurisdictions around the world today, zoning is the first step in the land development process: residential here, commercial there, and office over there. This is promoted as the most important determinant in advancing health, safety, and welfare and in protecting the public interest because of the power it has in separating *incompatible uses.* The concept of keeping incompatible uses started off in a logical manner—*do not build houses next to a coal-burning factory*—but over time the definition has become broadly applied to almost anything (e.g., keeping multi-family units away from single-family units). [10]

Only after the land uses have determined is subdivision taken into account, and this is only done on a parcel by parcel basis. What happens in this way, however, is that the subdivision patterns produce a street network that has no additional connectivity because the patterns are bounded by each individual parcel under consideration (i.e., there is no plan present that says *leave a street stub out here on your property for a future connection across another property*). Zoning, by definition, is a private matter.[11] To limit the planning of streets (which is by definition a public matter) to the confines of private parcels is one of the greatest errors—if not the greatest error—of our modern planning process. As new development occurs, it latches on to the existing street network.

When zoning occurs first and subdivision is determined on a parcel-by-parcel basis, the inevitable result is an unwalkable, unsustainable urban form, one that minimizes connectivity, minimizes street frontage, minimizes opportunities for vitality, minimizes the ease for redevelopment, and minimizes public space. The poster child of this urban form is the cul-de-sac. **Cul-de-sacs** are great at accommodating quiet, single-family detached houses, but that's it. By design, they are largely incompatible with other uses. This has been the dominant urban form in post-WWII America. Unfortunately, it coincided with a boom in population, production, and development, ultimately surrounding our cities with first, second, and third ring suburbs. When more development and people occupy a network of this type, that means the density of cars goes up, which worsens traffic problems. The only solution in this context then is to expand the capacity of each individual road by adding lanes, which spurs more development and more cars.[12]

But there is an alternative to this approach: putting streets first and land uses second. A master street plan is the first thing to consider in a streets-first process. In this way, as development occurs it is known that the resultant street network has built-in connectivity, built-in walkability, and built-in adaptability, so that in the future when things change (recall from the Introduction that things will change as much as you may not want them to) that change is readily absorbed and accommodated in a proven pattern of urban form. Zoning can adjust as it needs to on top of the street plan. People can move in or move out, buildings can shift around, and the street plan can be the constant background for that development. And it all works because the streets, blocks, and lots are a function of a time-tested dimensional DNA.

The Benefits of a Master Street Plan

There are many benefits to incorporating a master street plan into the planning process, including:

1. **Frees up municipal resources**: As a pre-approved subdivision plat, a master street plan streamlines the review process. This allows planning authorities to focus on other critical issues, like affordability and housing. Without a master street plan, every development must be reviewed as new, unnecessarily waisting time and soaking up resources. However, if the jurisdiction's subdivision plan is completed all at once, then as long as a

developer conforms to the plan the review time is minimal. If the developer wishes to deviate from the plan, they can do so, but they have to submit a variance.
2. **Saves developers and home buyers time and money**: As a pre-approved subdivision plat, developers can get their projects completed more quickly and at reduced cost, with the efficiencies and savings trickling down to the home buyers.
3. **Prescriptive, not postscriptive**: Rather than relying on after-the-fact tactics, once the harm has already been done, or ineffectual connectivity metrics, or parcel-by-parcel subdivision reviews, a master street plan ensures that a desired urban form will materialize.
4. **Guides incremental development**: While a master street plan is established up front, its execution occurs over decades and centuries. As the city grows, a master street plan is there to guide that growth.

Designing a Master Street Plan

It has been shown that streets provide important functions beyond those of mere transportation purposes and that they are the longest-lasting elements of a city's infrastructure. Now the question we have before us is *how does one design a master street plan?* The best way to determine that is to look at precedent, to look at the best examples of town planning the world has to offer. There are many sources one can to turn to to assemble this list of precedent, but for this paper we are focusing on those neighborhoods selected by the American Planning Association as the most walkable, sustainable, and enjoyable.[13]

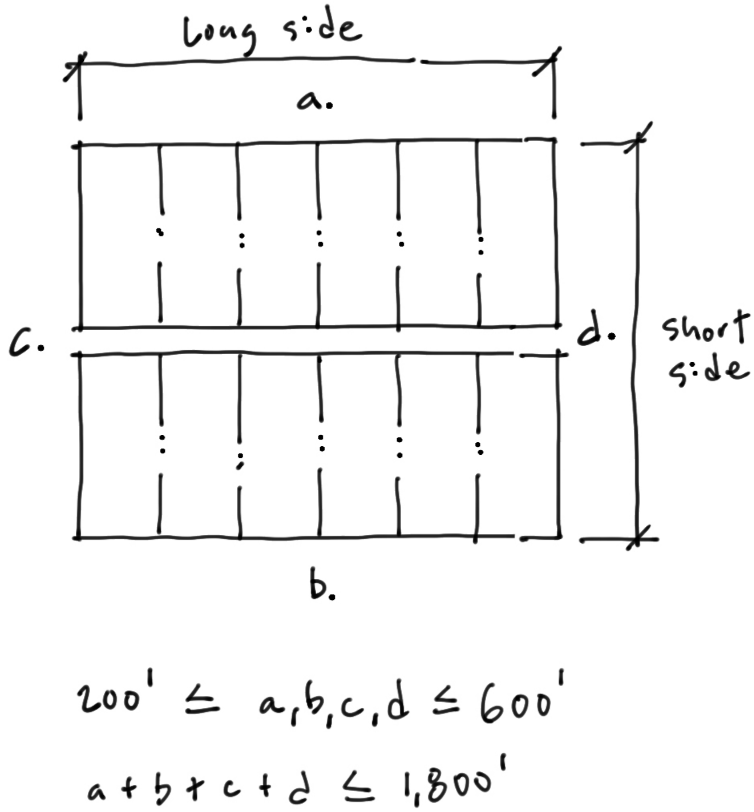
The following is a partial list of precedent used for analysis in this paper which includes many of the neighborhoods designated by the APA as "***Great Places of America***" as well as other cities from around the world to broaden the scope of research: Amsterdam, Aosta, Ashland, Austin, Baltimore, Banff, Bangkok, Barcelona, Beaufort, Beckley City, Boise, Boston, Brunswick, Buenos Aires, Cacalchen, Cairo, Cape Town, Charleston, Cincinnati, Durango, Evanston, Forest Hills, Franklin, Frederick, Grand Rapids, Hattiesburg, Innsbruck, Istanbul, Key West, Kuwait City, Lafayette, Madison, Marfa, Mason City, Miletus, Mones Cazon, Montgomery, Nantucket, New Delhi, New Orleans, New York, Oak Park, Owatonna, Paragonah, Paris, Providence, Riverside, Savannah, Siloam Springs, Spokane, St. Augustine, Staunton, Vienna, and Walla Walla.

Analyzing precedent

These precedents have all the characteristics of great places: they possess some combination of walkability, sustainability, enjoyability, beauty, and vibrancy. By carefully analyzing their urban forms—their streets, lots, and blocks—we can learn what urban forms yield the best urbanism. By measuring block sizes and their geometries, right-of-way widths and their networks, we can determine the ideal structure of the best cities in the world. **While the precedents mentioned here represent the spectrum of urbanism—from small towns to large cities, from East to West—they possess uncanny similarities in their mutual urban forms. Our research reveals a universal law of urbanism, a common dimensional DNA, that results in their successes. That universal law is presented below in four major rules: block size, block geometry, right-of-way width, and alleys. These rules can be applied to small developments, entire neighborhoods, or whole cities.**

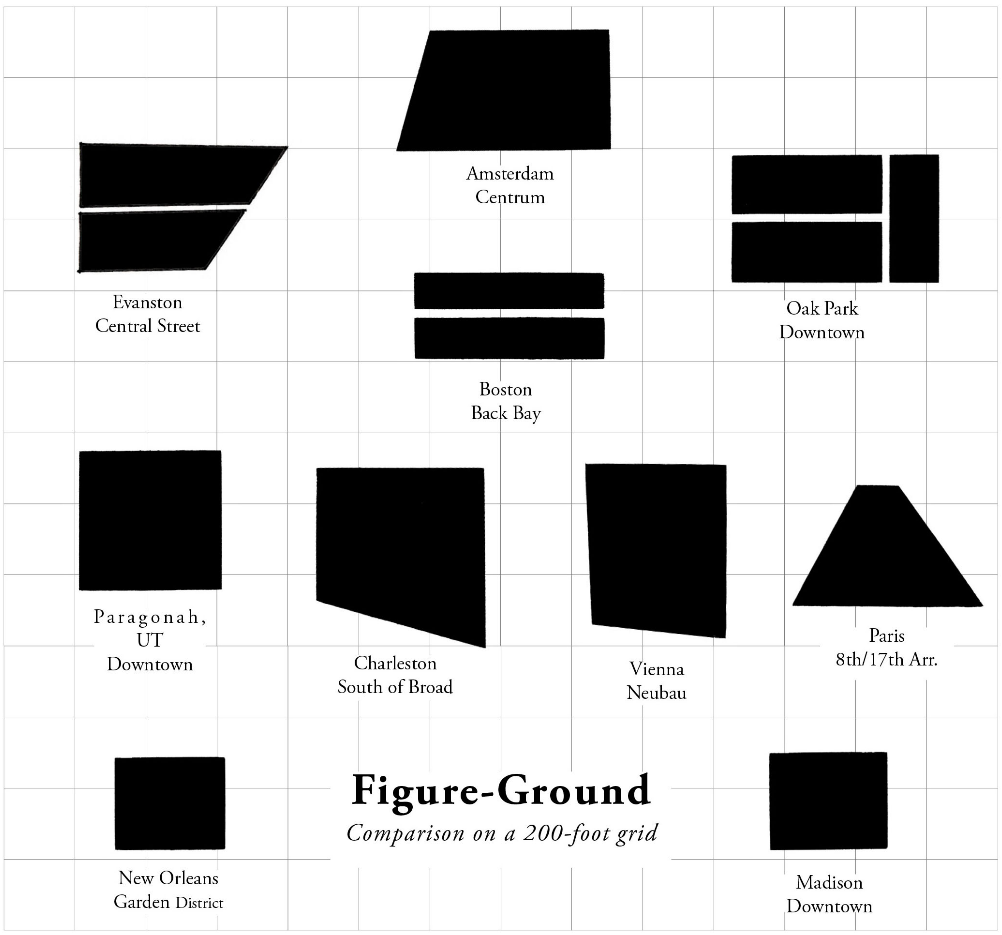
The Dimensions of Good Urban Form
Rule #1: Block Size

Blocks should have sides greater than 200 feet and less than 600 feet, with a perimeter less than 1,800 feet.

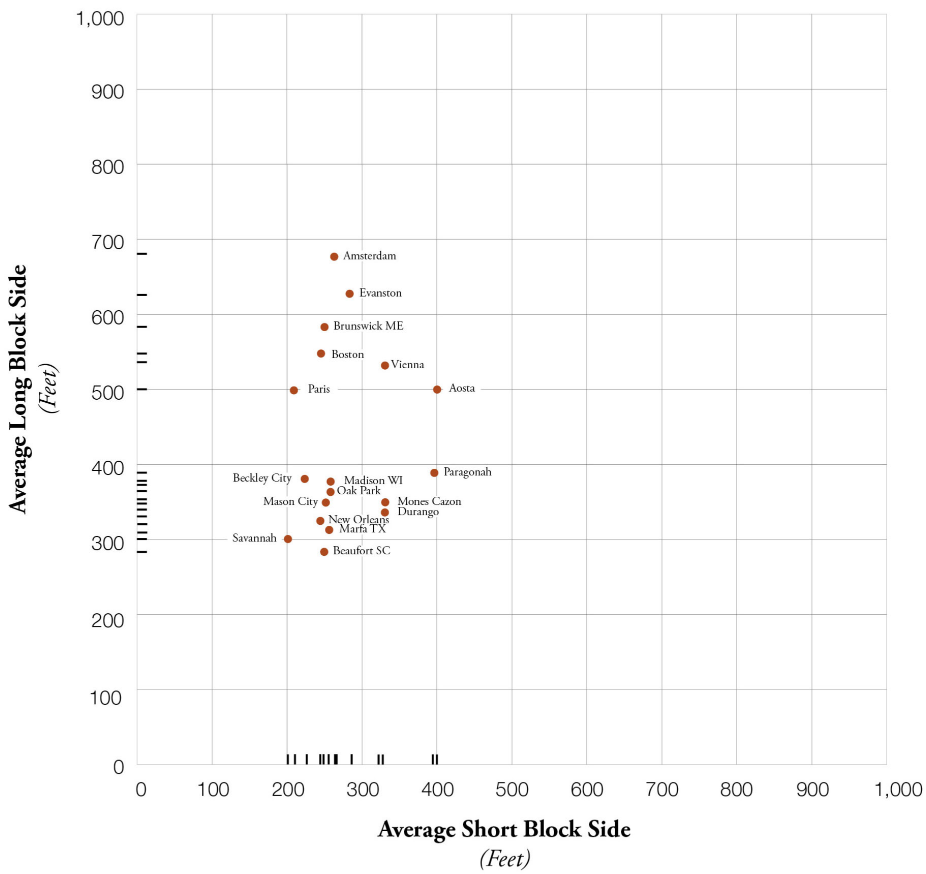


Perhaps 80% of good urban form is embedded in this one rule; no other metric is as powerful as this one. Many of the desired aspects of urbanism, including walkability, adequate street frontage, and adaptable land subdivision, are a distinct function of block size. If one were to implement only one rule, this would be it.

The image below compares the median-sized blocks of various neighborhoods. At first glance, some of the blocks are a little more angular than others, some have alleys while some don't, but overall they are remarkably similar. They are all relatively the same size, relatively the same shape. Notably, in some cases they are indistinguishable: for example, the Garden District of New Orleans and downtown Madison, Wisconsin, utilize essentially the same block. And Charleston and Vienna are barely distinguishable from one another. A worldwide pattern is already evident here.



Now let's compare these blocks in another way. We can reduce median block sizes to a point on a graph (refer to the image below), with the average short block side for each neighborhood falling along the x-axis and the average long block side falling along the y-axis. If block size was random or did not factor in determining great cities, we would expect to see these points dispersed haphazardly, but amazingly they huddle together in one area. **This is not an outcome of the universe telling us how big a block should be; instead, it is a product of millions of decisions made by people and planners over the centuries, fine-tuning the dimensions of urban form. The consensus is astonishing.**



Jane Jacobs, the venerable New York journalist and observant urbanist, stated in her famous book *The Death and Life of Great American Cities*:

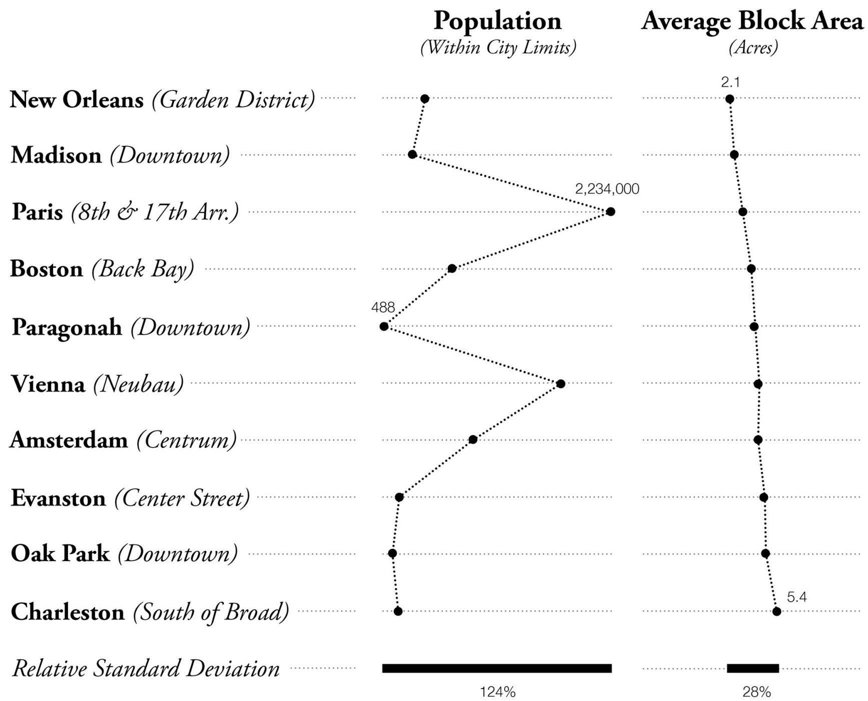
> *"Frequent streets and short blocks are valuable because of the fabric of intricate cross-use that they permit among the user of a city neighborhood. Frequent streets are not an end in themselves. They are a means toward an end... Frequent streets are effective in helping to generate diversity only because of the way they perform.*

The means by which they work (attracting mixtures of users along them) and the results they can help accomplish (the growth of diversity) are inextricably related. The relationship is reciprocal."

Our analysis above reveals the numbers behind Jacobs's observations. Our study of great places shows that on average their blocks fall somewhere between 200 feet and 600 feet. As one additional constraint, their perimeters are bounded by about 1,800 feet (e.g., a square block 600 feet on each side has a perimeter of 2,400 feet which falls outside the range). **What is incredible about this is that our study incorporates places not only all over the world but places that were built at various times, from decades or even thousands of years ago. Yet the data show us that the range we are talking about isn't 0 to 10,000 feet, or 10 to 5,000 feet; it is a tight 200 to 600 feet.**

If we break it down between each side of a block the variances get even tighter. The figure above also tells us something about block orientation. The average short side range is only 200 feet to 400 feet; the average long side range is larger: 300 feet to 700 feet. The reason for this is that typically the short side is a function of a lot's depth. Because blocks are typically composed of two lot tiers and because lot depths typically fall in the 100 ft to 200 ft range, this narrows the overall range of block width. Block length, however, is a function of lot width and can change simply by appending more lots side by side. In this case, the block length can easily expand without sacrificing lot efficiency. This is why block length falls within a higher range.

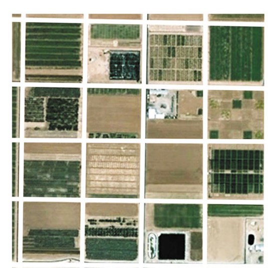
It is a common misconception to assume that small blocks imply high population density and big blocks imply low population density.[14] As it turns out, block size has little relationship if any to population. In the analysis shown below, the populations span a wide spectrum, ranging from 488 people in Paragonah, Utah, to 2.2 million people in Paris, France. However, amongst all the cities shown, their block sizes are in an incredibly tight range, with a relative standard deviation[15] of only 28%. Essentially, what is being reflected here is a universal urban form: **all these cities represent the spectrum of everything ever built on the planet, and yet they're all operating within the same relative block size.**



Finally, we can see how differently a 400-foot square block can be used (refer to the image below). While all the blocks represented are the same size and shape, they have each come to accommodate an incredible range of land uses. One is a farming block in Arizona, the other a small town in Utah, and the other the thriving downtown of Chicago. Same block, different use.

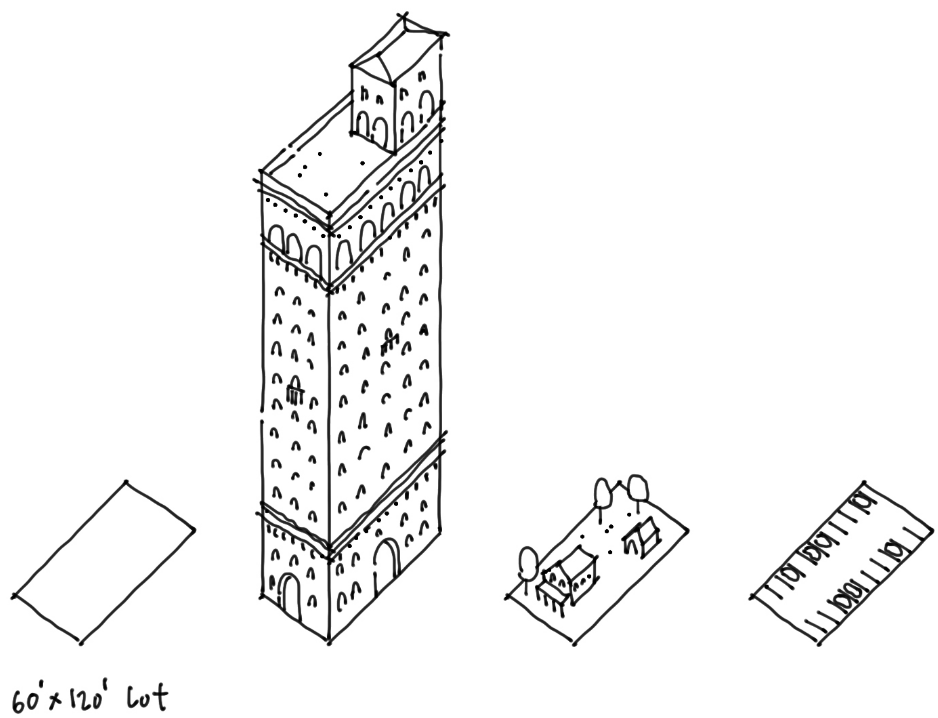
Paragonah, UT

Downtown Chicago



Farming blocks in Arizona

This discussion of block size also leads to one on lot size. The dimensional adaptability of blocks continues down to the dimensional adaptability of lots. For example, a standard 60-foot by 120-foot lot is a surprisingly versatile unit of land. That lot could accommodate everything from a house to a parking lot to a skyscraper. While the heights and land use intensities vary, the critical point is that all these uses essentially occupy the same foot print. In plan view, a house with a yard can take up just as much space as a 40-story skyscraper.



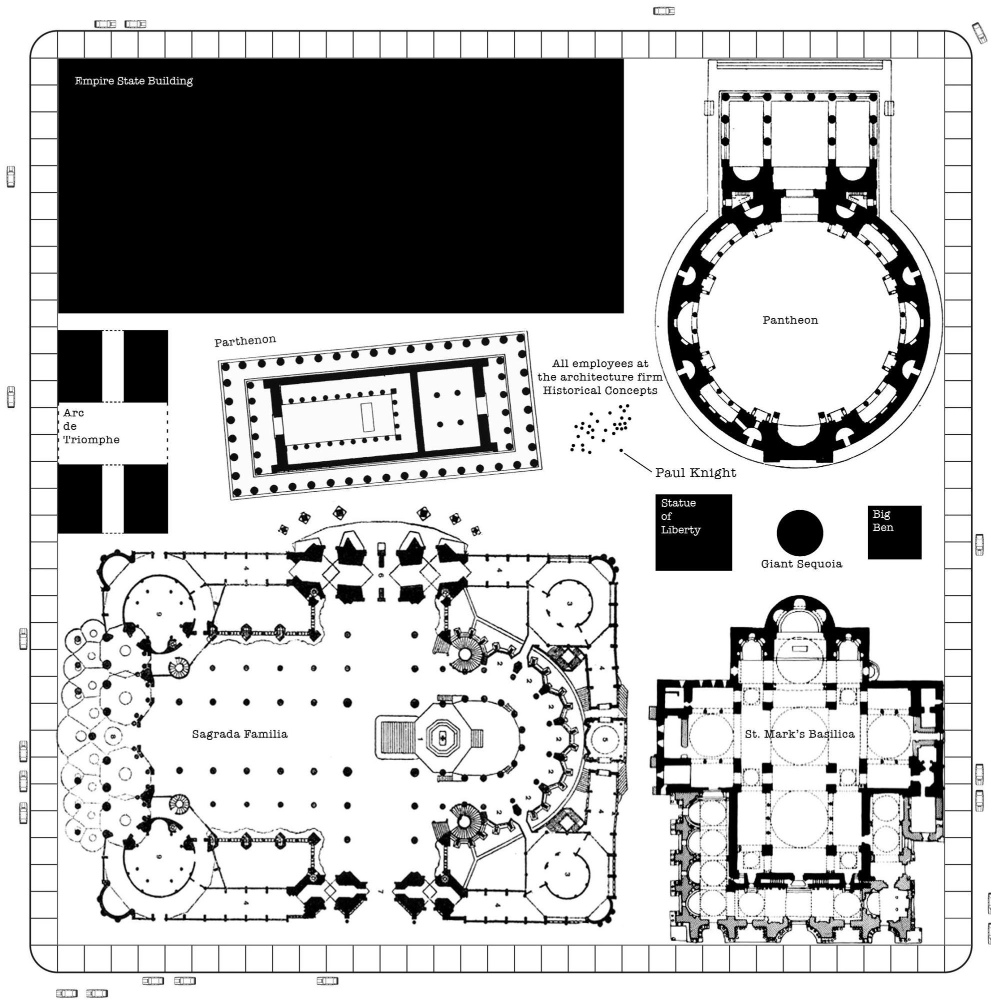
Lot widths in multiples of 12 are ideal, dimensionally, because 1) they can accommodate various land uses, 2) standard building dimensions (which are based on units of 12) and 3) superior mathematical fungibility.[16] Furthermore, lots work best when the narrow side faces the right-of-way. Some reasons for this include:

1. It is more economical for a lot owner to own a smaller portion of street a right-of-way than otherwise.
2. Smaller frontage units allow more lot owners to face the street per unit length which translates into more opportunities for a vibrant mix and proximity of land uses.

3. Smaller frontages also allow for more access points (shop fronts, front doors, etc) which further contributes to vitality.
4. Building layouts tend to favor elongated rectangles over squares for various reasons including the limits of natural light and the proportions of individual rooms (not every room in a house or office needs to be a square).

Let's now leave the discussion of small blocks and consider what happens when blocks are too big. In **Salt Lake City**, Utah, the blocks are 660 feet on a side with a perimeter of 2,640 feet. This clearly does not pass our *Rule #1*. This block depth implies a lot depth of 330 feet. As we have just seen with the discussion about lot size, there are very few things that we build in this world that require a 330-foot lot depth. Because of that, in Salt Lake City what has happened over time is that property owners along the edge have sold the back half of their lots. This has resulted in an inner block of development, but this interior development does not benefit from the exposure that a street provides; consequently, they do not contribute to the vitality of Salt Lake City's streets.

The diagram below further illustrates the absurdity of Salt Lake City's block size.



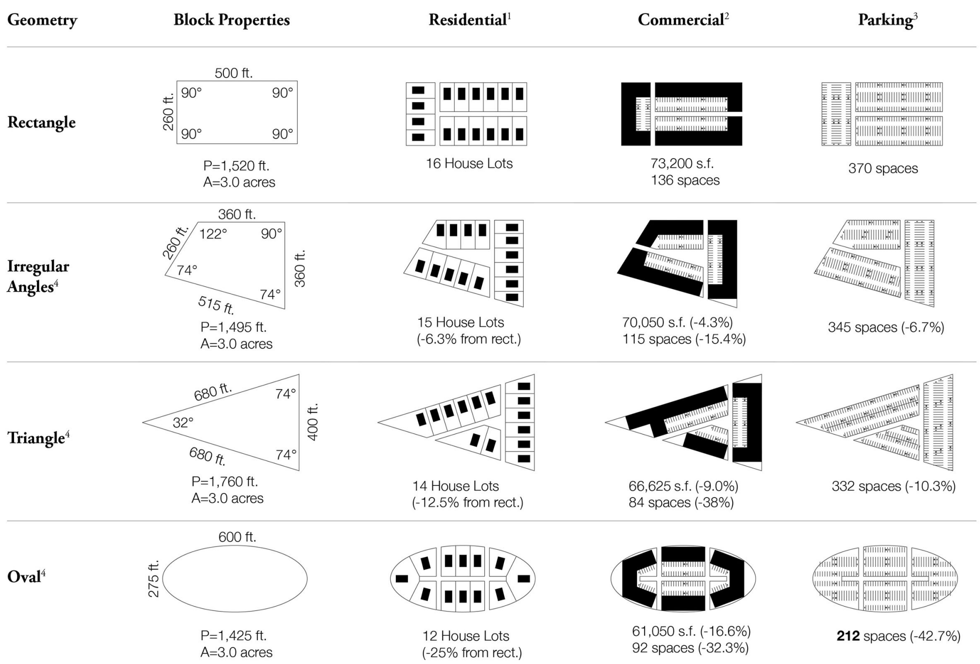
Recall that a block is defined as an area of private property surrounded on all sides by public rights-of-way. Let's apply that definition to the blocks of **Alpharetta** in suburban Atlanta, Georgia. The urban form of Alpharetta possesses innumerable cul-de-sacs, and by definition cul-de-sacs do not connect through, they stop and avoid connection. This results in block sizes of enormous scale which looks all the more ridiculous even when compared to the over-sized blocks of Salt Lake City (see image below). Given the weight that block sizes have in urbanism and based on these observations alone, it is safe to say that Alpharetta will never possess the qualities of a walkable, vibrant, mixed use community; it simply does not have the urban form to support it.

Rule #2: Block Geometry

> *Blocks should be composed of straight line segments with preference given to rectangles; a long side to short side ratio of 1.5:1 or greater is also preferred.*

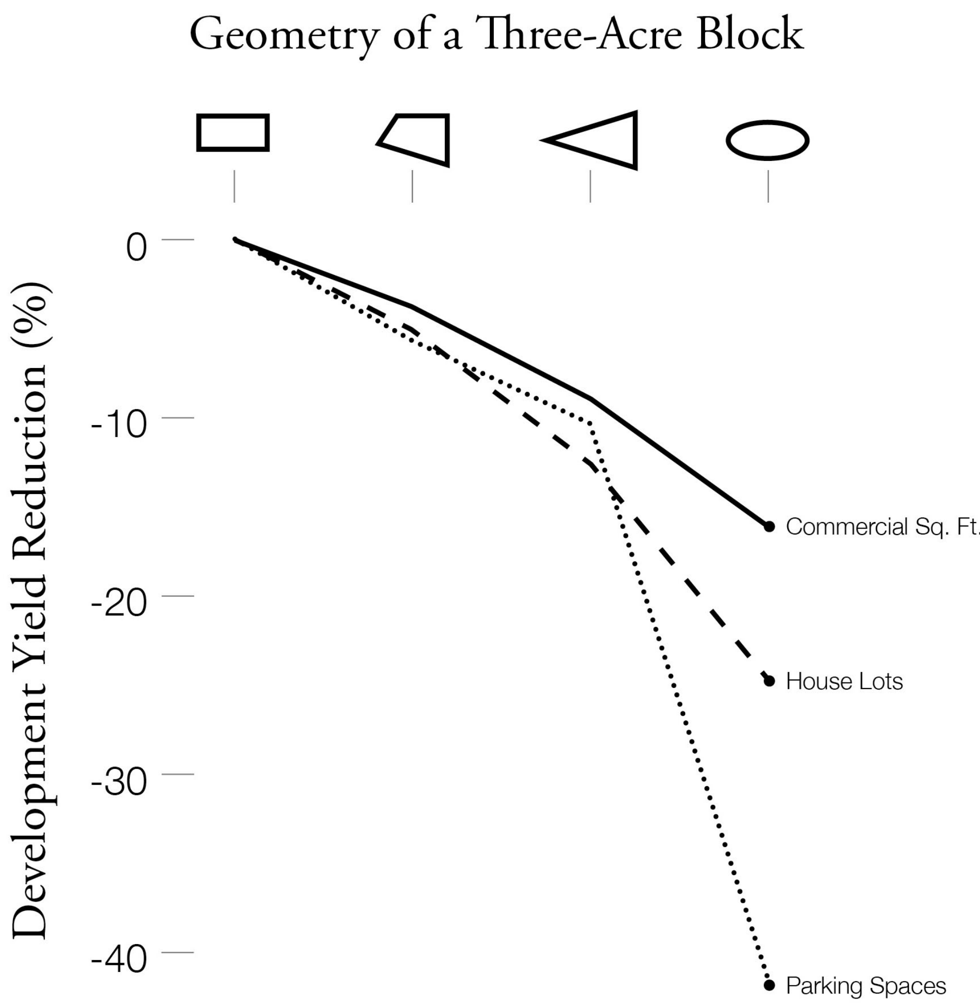
In our study, we found the majority of blocks were straight-sided and rectangular. Why? Consider first that rectangles are everywhere. They're in our buildings, bedrooms, TVs, doorways, drawers, chairs, books, papers, iPhones, parking spaces, shipping boxes, agricultural fields, computers, briefcases, CCDs, and rugs. Rectangles are fairly useful forms for us. The commissioners of Manhattan in 1811 recognized as much saying that "straight-sided and rightangled houses are the most cheap to build and the most convenient to live in."[17] That statement is as true and relevant today as it was then or as it was 2,000 years ago.

Secondly, we can consider the relative yields of different block geometries (rectangles, irregular angles, triangles, and ovals). We isolated the variable of geometry by holding the area of the blocks constant. We tested the resultant blocks against three different land uses: residential, commercial and parking. We attempted to keep the physical parameters of each land use the same across all he blocks. The results are shown in the table below.



1. Lots 60' x 120' with alley access.
2. Building footprint 60 feet deep; right angle is favored but 45° is minimum.
3. Parking spaces 10' x 20' with 20' drive aisles.
4. Figures in parentheses represent the blocks performance relative to a rectangular block.

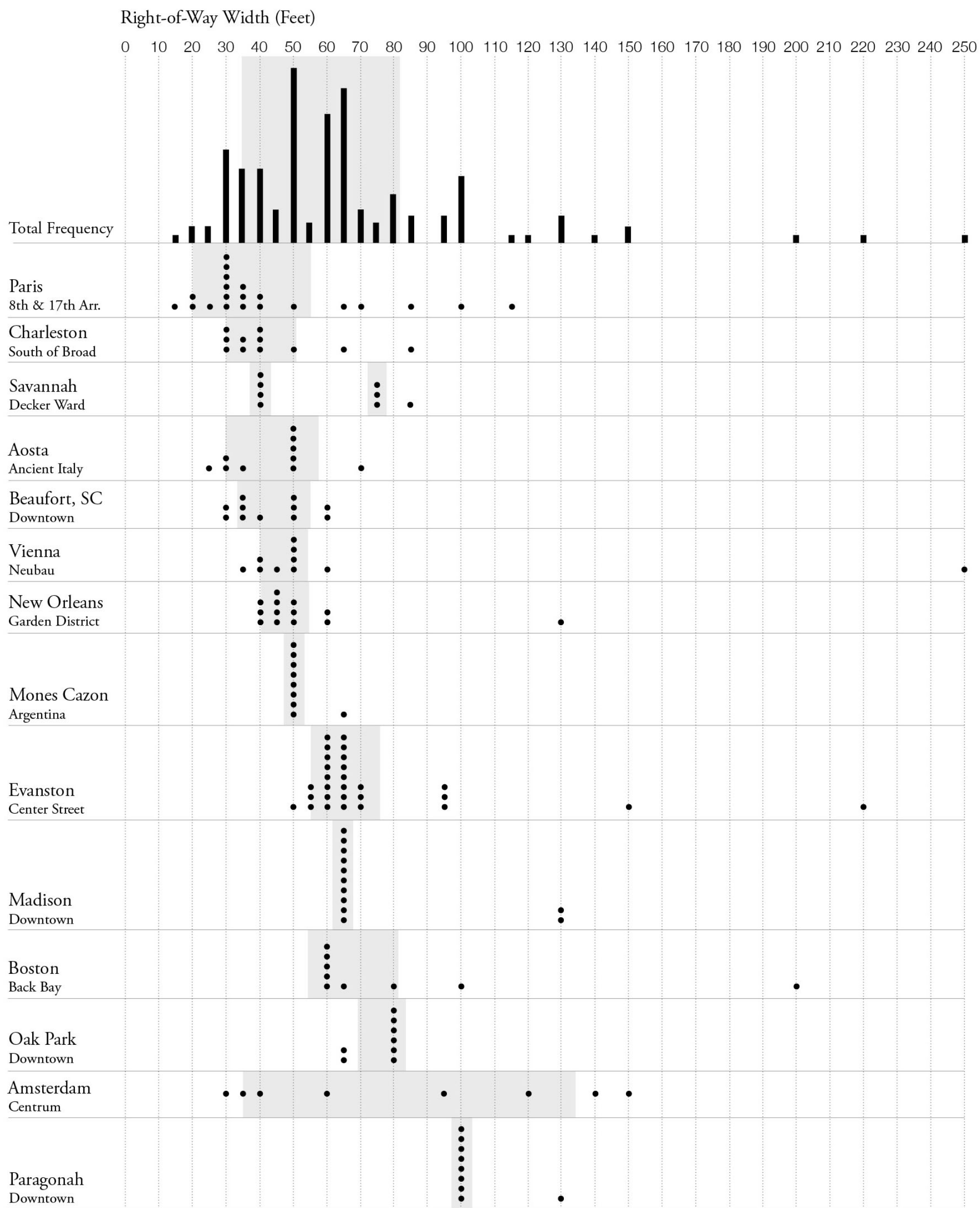
In terms of houses, the rectangular block can accommodate 16 standard house lots, the irregular block can accommodate 15, the triangular can accommodate 14, and the oval can only accommodate 12. The decline in efficiency is easily seen and it continues across all land uses (see the graph below). The further one gets away from the rectangle, the less efficient the block becomes. The reason for this is purely geometrical: there is a "flat packing" efficiency created given all the rectangles we have in our lives. These objects (buildings, beds, books, etc) perfectly pack into corners, leaving no waste of land area. Few buildings in this world are truly curved: most are actually *faceted*, meaning they are made up of rectangular building materials (bricks, beams, plywood) that are turned at each juncture along a curve at some desired tolerance.



Rule #3: Rights-of-way

Most rights-of-way should have a width between 40 feet and 80 feet; a limited number of rights-of-way may be larger or smaller.

The table below[18] shows the distribution of rights-of-way of varying widths across our sample of precedents. The dots represent individual rights of way, the bars represent the total numbers, and the gray shaded areas represent the standard deviation about the mean. By comparing the total frequency of rights-of-way across these varied great places, it is evident that the majority fall between 40 feet and 80 feet, with many being around 60 feet.



A 60-foot right-of-way is incredibly versatile. It can be a deserted country road, a suburban street, or a major urban thoroughfare.

381st Avenue, Decorah, IA

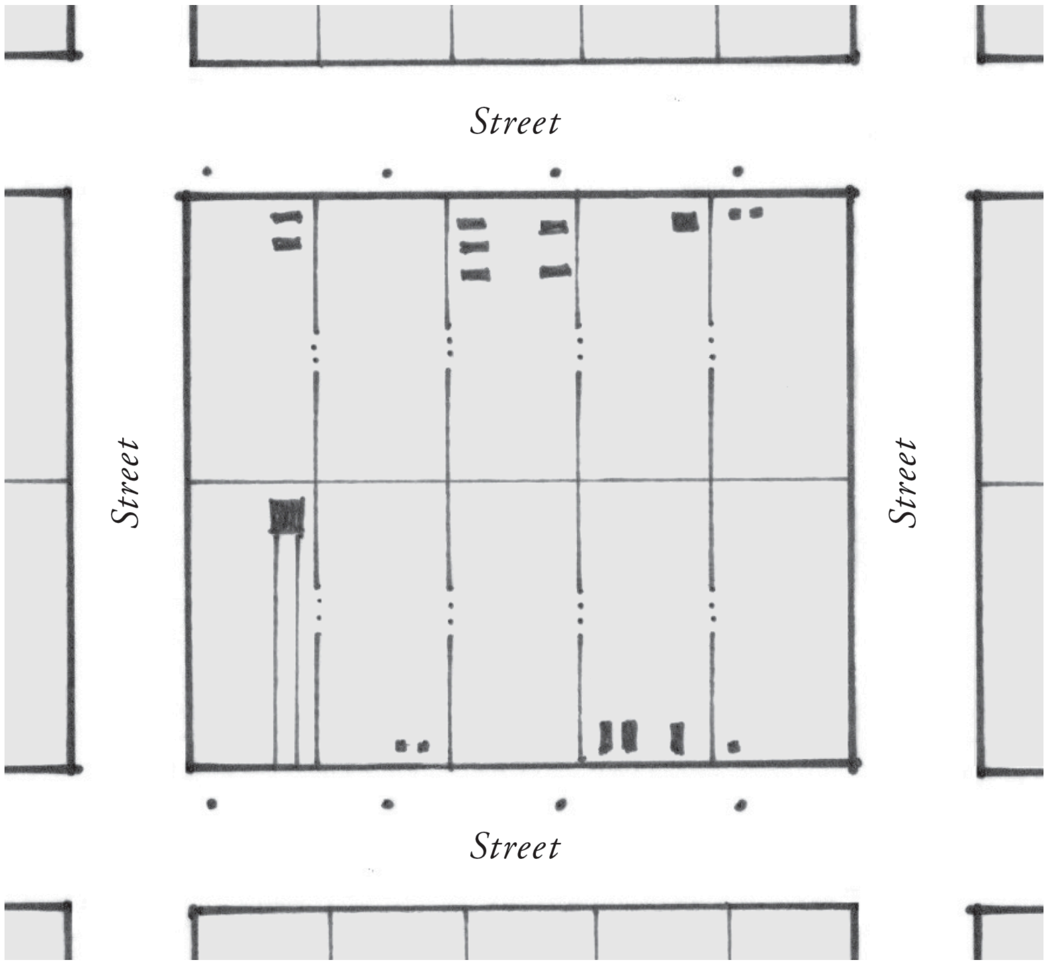
Bowen Street, Providence, RI

41st Street, New York, NY

Rule #4: Alleys

> *Alleys should be between 10 and 20 feet in width and be present in most, if not all, blocks.*

Alleys are the unsung heroes of good urbanism. They increase connectivity, access, efficiency, sanitation, light, and air. Take, for example, **Commonwealth Avenue** in **Boston**, Massachusetts, one of the most beautiful streets in the world. It is essentially a 100-foot linear park flanked on either side by streets, sidewalks, front yards, and townhouses. Such a beautiful, manicured scene is only possible because of the alleys dividing the blocks. Alleys are the ideal locations for the necessary unpleasantries of modern urban life including power lines, parking spaces, dumpsters, water meters, and fire escapes. Without alleys, all these objects would need to occupy the front of the lots, interfering with the very face of the city and causing not only aesthetic harm but functional drawbacks.


Street
Street
Street
Street

Alleys provide additional access. Without alleys, all access (including curb cuts) must occur at the front of the lot. With alleys, access can occur in the back of the lot, freeing the front of the lot for broader porches or wider storefronts. Additionally, these consolidated access points for vehicular traffic make for a more walkable urbanism as there are fewer curb cuts (i.e., conflict points) with pedestrians.

Manhattan provides a good lesson of what happens when alleys are not incorporated into the urban form of a city. As the image below shows, trash pick up is forced to occur on the sidewalk which is not an ideal experience anyone: worker, resident, or tourist.

Note by the author: Consider whether alleys should be a "rule" or a "suggestion" as they are not ubiquitous across the study areas. There are more discussions that need to be added to this paper including street network, parks, etc. This discussion on alleys could be moved there, leaving three rules and, say, seven suggestions.

Rules 5-10:

Rules 1-4 should be considered "critical:" failure to follow them will likely result in a "failed" urban form (i.e., one that is unwalkable, unadaptable, etc).

Rules 5-10, however, can be thought of as "nice to haves" or "next level aspects". They can help elevate an urban form to a higher standard. These rules are still in the process of codification. We list them below as a preview of what's to come with our ongoing work.

Rule #5: The Art of the Plan

A discussion on the overall street network of a neighborhood or city. Comparing the relative pros and cons of grid irons, *City Beautiful*, medieval patterns, etc.

Rule #6: Parks and Civic Institutions

The size, placement, and interaction of parks and civic institutions within a street plan.

Rule #7: Existing Natural Features

How should street plans be designed with respect to geography, topography, solar orientation, rivers and creeks, etc?

Rule #8: Autonomous Systems

How should street plans be designed with respect to interstate highways, railroads, airports, power easements, etc?

Rule #9: Extra-Territorial Considerations

The extent of a master street plan is limited to the issuer's jurisdiction (e.g., within the boundary of a city). How do the outlying areas interact with such a plan? And vice versa?

Rule #10. (Reserved For Discovery)

And because we've been conditioned to think in "10s."

Appendix: Enabling Statutes

City planning is divided into two domains: **public** and **private**. This paper addresses the distribution and design of the public domain and the elements thereof including its boundaries, streets, public places (like parks and civic buildings), and public monuments. The private domain comprises everything else: people, buildings, signage, land uses, etc. The public domain is more or less permanent; the private domain is more or less changeable.

The history of city planning in the United States provides an invaluable lesson in this regard. In the early 20th century, city planning was just being organized as a profession. The organizers developed model planning laws that correctly divided cities into their public and private components. But over time the profession has departed substantially from this as it now focuses heavily on a set of documents that, in their origin, were limited only to the regulation of private property (just half of the planning problem). To this we are referring to Zoning: that leviathan released onto the modern planning world which has devoured more good intentions and proper planning principles than all ill-informed architects and planners combined, leaving in its wake unsustainable, unadaptable, unwalkable, placeless sprawl.

Lessons from America's Enabling Statutes

Cities of the post-industrial 1800s around the world were suffering from similar health crises: people were living next to where they worked, and because they worked in unsanitary, unhealthy, unsafe environments they were literally dying from the proximity. To make matters worse, many lived in overcrowded tenement houses without adequate light, air, or sanitation. At that time, people, for the most part, lived in cities by necessity, not by choice. Many cities were dangerous, filthy, and unpleasant places to call home. As the world urbanized, the crisis worsened.

To address these real concerns and stave off future ones, many cities in America began drafting and adopting their own zoning regulations. The concept of zoning—the regulation of private property including land uses and building volume—was first utilized on a city-wide scale in New York when its **Zoning Resolution** was passed in 1916. The *Resolution* sought to separate incompatible uses from one another (like coal-burning factories from houses) and to regulate height and bulk of buildings for the purposes of preserving light and air for the city's streets and parks.

In an effort to achieve consistency and efficiency, an **Advisory Committee on City Planning and Zoning** was formed under President Herbert Hoover to create model laws that could be adopted across the country. These laws would do two things: 1) provide a national framework of planning and design principles, and 2) provide a vetted legal basis for utilizing these principles and effectuating physical plans. The committee correctly saw the city planning problem as one divided between public and private property and so created two Enabling Statutes to address each of these domains: the **Standard City Planning Enabling Act (SCPEA)** to address all public property and the **Standard State Zoning Enabling Act (SSZEA)** to regulate all private property.

The intention behind these two documents was for the SSZEA to be subservient to the SCPEA, as the SCPEA was viewed as the parent document being broader in scope.

To that end, the definition of "comprehensive plan" is originally defined in the SCPEA in this way:

> *"It shall be the function and the duty of the commission to make and adopt a master plan [a comprehensive plan]. Such plan...shall show the commission's recommendations for the development of said territory, including, among other things, the general location, character, and extent of streets, viaducts, subways, bridges, waterways, water fronts, boulevards, parkways, playgrounds, squares, parks, aviation fields, and other public ways, grounds and open spaces, the general location of public buildings and other public property, and the general location and extent of public utilities and terminals, whether publicly or privately owned or operated, for water, light, sanitation, transportation, communication, power, and other purposes; also the removal, relocation, widening, narrowing, vacating, abandonment, change of use or extension of any of the foregoing ways, grounds, open spaces, buildings, property, utilities, or terminals; as well as a zoning plan."*[19]

While the list is indeed comprehensive, it can be broken down into a few broad categories including "public ways", "public buildings", "public property", "public utilities", and "zoning". *Zoning* is originally defined in the first sentence on the first page of the *Zoning Primer* written in 1926 as such:

> *[Zoning is] "the application of common sense and fairness to the public regulations governing the use of private real estate."*

"*Private real estate.*" Going back to the definition of comprehensive plan, the division of the city planning problem is clearly delineated here between public and private. Each of the Enabling Acts has an associated critical map with physical implications: The Zoning Act utilizes a zoning map; the City Planning Act utilizes a master street plan (see discussion of master street plans in the previous chapter).

These Acts, known together as the Enabling Acts, formed an excellent foundation for American planning. Unfortunately, their the plan was not fully followed through and the documents' powers, once mutual or weighted toward the public domain, has shifted dramatically to focus almost solely on zoning.

How and why did this happen? Seeing zoning as the most pressing issue at the time, the SSZEA was published in 1926 and then only later, in 1928, was the SCPEA released. But in their haste the drafters of these foundational documents put the cart before the horse: as zoning's promise and influence took over the planner's mindset and toolbox, it garnered more attention, leaving the critical pieces found in the SCPEA ultimately disregarded. There was little regard as to where or how land uses would connect up, or how the respective urban forms of new towns or cities would be utilized once those land uses changed over time.

In the 1947 decision of Bishop vs. Board of Zoning Appeals of the City, the court went so far as to redefine "comprehensive plan" (thus circumventing the SCPEA all together) as:

> *"A general plan to control and direct the use and development of property in a municipality... by dividing it into districts according to the present and potential use of the properties."*

"*Use*." Land use. Zoning. According to this definition, one no longer needed to provide a master street plan (that framework, structure, or skeleton of urban form that organizes a town or city for centuries and millennia) within a comprehensive plan; instead, one only needed a zoning map. Today, the zoning map is the foundation of almost all comprehensive plans.

The problem is that land uses are fleeting. They come and go. They are a variable. It is no wonder then why so many comprehensive plans today so quickly go outdated—it is the variable of land uses that forces them to keep up. **Great American cities like Philadelphia, New York, Washington, and Chicago did not begin life with a zoning map—they materialized through the rigorous and patient execution of a master street plan.** The planners and designers for those cities created a framework of streets that would prove to adapt to a multitude of unforeseen futures, including a multitude of unforeseen land uses (the Commissioners of New York in 1811 could not possibly have foreseen the coming of the skyscraper; General James Oglethorpe, when laying out the town of Savannah in 1732, could not possibly have predicted the sizes of dumpsters and waste-management trucks that work so well within the alleys he ultimately drew).

It is imperative for the success of cities that a master street plan precede a zoning plan. A planning process that puts zoning first and land subdivision second will result in unsustainable, unadaptable, and unwalkable urban forms. It is the critical point of this paper that land subdivision be considered *before* land use. It is the public framework of streets and blocks that must be designed in meticulous and rigorous detail. Many of those details are addressed in this paper.

Any city-wide, town-wide, or neighborhood-wide plan (by any name, be it comprehensive plan, master plan, or the like) that does not have a land subdivision pattern as its foundation, regardless of scale, location, time, or money, will ultimately fail to live up to the expectations of the designers or the challenges that history will inevitably throw at it. One cannot create a solid foundation for a city based on the variable of land uses; one can only do this using the permanence of the public framework by directly placing and shaping its boundaries, streets, public places, and monuments.

History is clear: land subdivision must take precedent over land use. Then, and only then, will a neighborhood or city be allowed to grow and evolve into something great, unique, sustainable, and adaptable, just as the development of all the great examples of urban form throughout history have done. Cities are not about projects, they are fabric. It is the primary mission of the planner to establish and promote that fabric; the lessons and principles outlined in this paper (which are all based on extensive analyses of urban forms that vary by scale, time, and location) acts as a guide in that regard.

Appendix: Exceptions

This paper addresses various "rules" of planning, but it is important to note that they do not have to be strictly followed 100%. Exceptions will happen, and that's ok; the realities of life and geography are messy. A general goal would be to follow the rules, say, 90% of the time.

For example: say a neighborhood comprises 20 blocks. If 19 of those blocks are 300 feet by 400 feet (which follow the block size rule) but one is 600 feet by 800 feet (which breaks the rule), the neighborhood as a whole follows the rule sufficiently.

However, if it were the other way around (19 out of the 20 blocks are oversized 600 feet by 800 feet), that's when you will lose the all benefits of small blocks as outlined in this paper.

There is a grey area between those two examples within which it is safe to operate.

Appendix: Highly Composite Numbers

Appendix: Highly Composite Numbers

Dimensions are numbers with strings attached to the real world. They are a way for us to record the sizes of things, whether as a record of something built or as a requirement of something to be built. In the applied mathematics of the built environment, dimensions are one of the primary tools. They allow us to manipulate the environment first conceptually before doing it physically; we can combine, extend, divide, or multiply lots with a simple calculation. This act of manipulation is *design*. Easier methods of manipulation will make the design process that much more efficient. The search for a better method of manipulation (a better system of dimensions) can therefore begin as an exercise in finding the most flexible numbers.

Simply, frankly, mathematically, unequivocally, the number '10' is not as flexible or as fungible as the number '12.' Ten has four divisors and can only be divided wholly by 1, 2, 5, and 10. Any and all other divisions will result in a remainder. Twelve, on the other hand, has six divisors and can be divided wholly by 1, 2, 3, 4, 6, and 12. Because of these additional divisors, **12 is a more workable and fungible number than 10; said another way, 12 has more utility than 10.** More divisors means a number is able to adapt to more situations, making it easier to respond to a range of needs. It is similar to the malleability of gold verses the brittleness of glass; glass does one thing very well, but gold can be shaped in numerous ways as necessary.

A.C. Aitken, Professor of Mathematics at the University of Edinburgh, described the dozen's benefits this way:

> *"[Twelve is] a number divisible by 2, 3, 4 and 6, while its square...144, divides by these and in addition by 8, 9, 12, 16, 18, 24, 36, 48 and 72, with all the consequences of economical and suitable use in parcelling, packaging, geometrical and physical construction, trigonometry and the rest, to which any applied mathematician and for that matter any practical man, carpenter, grocer, joiner, packer could bear witness"[20]. [The metric (base-10) system is] "a notably inferior*

one; it cannot even express exactly for example the division of the unit, of currency, metrical or whatever, by so simple, ubiquitous and constantly useful a number as three"[21].

Furthermore, numbers are repeatedly subjected to multiple subdivisions. Halving, for example, is perhaps most common; it is literally in our DNA (think about it). Twelve-hundred and its resultants can be halved four times before encountering fractions (1200 to 600 to 300 to 150 and finally to 75) while 1000 can be halved only three times (1000 to 500 to 250 to 125). But 'halving' is not the only common method of subdivision. Thirds and fourths make frequent appearances throughout our daily lives (e.g., measuring cups, clocks, music, money). With this in mind, we have analyzed numbers to see how they behave when subjected to successive iterations of subdivisions by quarters, thirds, and halves. That exercise is shown in the two diagrams below (note that fractional numbers are "censored" out in black; only whole numbers are "passed on" to the next generation).

Common Subdivisions	**1/4** *Quarter*	**1/3** *Third*	**1/2** *Half*	**2/3** *Two-Third*	**3/4** *Three-Quarter*
1,000	250	[redacted]	500	[redacted]	750
750	[redacted]	250	375	500	[redacted]
500	125	[redacted]	250	[redacted]	375
375	[redacted]	125	[redacted]	250	[redacted]
250	[redacted]	[redacted]	125	[redacted]	[redacted]
125	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Common Subdivisions	1/4 *Quarter*	1/3 *Third*	1/2 *Half*	2/3 *Two-Third*	3/4 *Three-Quarter*
1,200	300	400	600	800	900
900	225	300	450	600	675
800	200		400		600
675		225		450	
600	150	200	300	400	450
450		150	225	300	
400	100		200		300
300	75	100	150	200	225
225		75		150	
200	50		100		150
150		50	75	100	
100	25		50		75
75		25		50	
50			25		
25					

Generational subdivision **is being defined here as subsequent divisions of both a number and its resultant "descendants"** (e.g., 600 is a descendant of 1,200, being half of 1200; 600 itself can then be subdivided further). The diagrams above reveal the superiority of 1200 over that of 1000: 1000 only has 5 generations of subdivisions, while 1200 has 14 (i.e., 1200 is almost three times more flexible than 1000). Additionally, the descendants of 1200 are themselves superior to the those of 1000. The numerical fungibility of "twelveness" passes from generation to generation. This is a simple observation and characteristic of mathematics and nothing more; however, it can be readily utilized in planning and architecture as we will show.

One cannot wholly divide 100 dollars or 100 feet into thirds. To do so leaves a remainder of money or land. If three people split 10 dollars, who is to end up with the leftover cent? If three property owners seek equal stakes in a 100-foot lot, where exactly should the lot lines be drawn? While geometry or pure algebra (with repeating decimal places) provide solutions, the applied mathematics of the real world is at a loss. In reality, the decimal ends eventually; whether that's 33.33 or 33.3333, there will be a remainder.

This problem is not trivial. Wars have been fought and lives have been lost over the placement of boundary lines. To artificially skew one way or another can lead to unintended and undesirable consequences. A system of land subdivision must strive for precision. Numbers that are highly composite are those that contain a high number of divisors, making them perfectly suited for systems that require divisions (such as land subdivision). Highly composite numbers are more properly outfitted for the qualities desired. And they are already heavily used elsewhere.

Our construct of *time*, for example, is built on highly composite numbers. There are 60 seconds in a minute, 60 minutes in an hour, and 24 hours in a day, all superstar numbers exhibiting extreme levels of divisibility. And there's geometry, too, with a circle being divided into 360 degrees. Those degrees are divided into 60 arc minutes and those into 60 arc seconds. Both time and geometry combine together to form our modern geographical coordinate system which divides up the entire surface of the earth into highly composite units.

The built environment, as its moniker implies, requires builders in order to materialize. The builder's task is to expand the scale of a drawing to full scale and to render a drawing using real materials. It is an intense process of communication between an architect, general contractor, their subs, and their subs' subs. Given all the complexities that already exist in the act of building, it is best to maximize simplicity and efficiency in the process where possible. With that said, it is easier to cut a sheet of plywood in half when its length is evenly divisible by two (half of a standard 96-inch sheet yields two sheets 48 inches wide); the mental math is manageable and the units themselves are highlighted on a tape measurer for easy transfer. Otherwise, half of, say, a 95-inch sheet is 47.5 mm, which requires good mental math or the use of a calculator (depending on the mental faculty of the subcontractor).

Highly Composite Numbers and the Metric System

MEASURE	DEVICE
12 in.	One foot
24 in. x 24 in.	Standard ceiling tile
48 in. x 96 in.	Standard sheet of plywood and drywall

16 in.	Stud spacing (courses with plywood)

Whether one is dealing with ceiling tiles, beams, studs, or sheathing, highly composite numbers like 12 become incredibly useful to work with in the field. Not only could that plywood be cut in half evenly, but it could be cut into thirds, fourths, sixths, eighths, twelfths, and so on. Ceiling tiles measuring 24 inches have a better chance at coursing out in a room of similar number than otherwise (saving the need to cut the tiles).

The task here is to incorporate this extant preference for highly composite numbers into a unified, efficient, and practical system of land subdivision. This is by no means the first time that highly composite numbers have been promoted in this way. **Plato**, in Book V of his *Laws* written 360 BCE, sought to apply the number 5040 to a city's citizenry and land area, stating:

> *"We will fix the number of citizens at 5040, to which the number of houses and portions of land shall correspond. Let the number be divided into two parts and then into three; for it is very convenient for the purposes of distribution, and is capable of fifty-nine divisions, ten of which proceed without interval from one to ten. Here are numbers enough for war and peace, and for all contracts and dealings. These properties of numbers are true, and should be ascertained with a view to use."*

As he wraps up his book, Plato extends this power of number and arithmetic to every facet of life:

> *"There is no difficulty in perceiving that the twelve parts admit of the greatest number of divisions of that which they include, or in seeing the other numbers which are consequent upon them, and are produced out of them up to 5040; wherefore the law ought to order phratries*[22] *and demes*[23] *and villages, and also military ranks and movements, as well as coins and measures, dry and liquid, and weights, so as to be commensurable and agreeable to one another. Nor should we fear the appearance of minuteness, if the law commands that all the vessels which a man possesses should have a common measure, when we consider generally that the divisions and variations of numbers have a use in respect of all the variations of which they are susceptible, both in themselves and as measures of height and depth, and in all sounds, and in motions, as well those which proceed in a straight*

direction, upwards or downwards, as in those which go round and round. The legislator is to consider all these things and to bid the citizens, as far as possible, not to lose sight of numerical order; for no single instrument of youthful education has such mighty power, both as regards domestic economy and politics, and in the arts, as the study of arithmetic. Above all, arithmetic stirs up him who is by nature sleepy and dull, and makes him quick to learn, retentive, shrewd, and aided by art divine he makes progress quite beyond his natural powers."

A bit more recently than Plato, the **Lexicon of the New Urbanism** references the utility of six in a proposal to use six-foot rods for lot widths.[24]

For our purposes here, we are proposing that the dimensions of all the elements of urbanism (blocks, streets, buildings, rooms, etc.) be functions of highly composite numbers (namely being divisible by six or 12). This helps to ensure, at least to within a half unit, that designs will be efficient and sustainable through the mathematical properties of coursing, packing, and ease of calculation. A six-foot grid could be draped upon a landscape, much like the **American Land Ordinance of 1785**, with boundaries, buildings, streets, parking spaces, and bedrooms all snapping to their corners.

Bibliography

Advisory Committee on Zoning. *A Standard State Zoning Enabling Act* (Washington: Department of Commerce, 1926).

Advisory Committee on Zoning. *A Standard City Planning Enabling Act* (Washington: Department of Commerce, 1925).

Advisory Committee on Zoning. *A City Planning Primer* (Washington: Department of Commerce, 1928).

Alexander, Christopher. *The Nature of Order: An Essay on the Art of Building and the Nature of the Universe* (Berkeley, CA: The Center for Environmental Structure, 2002)

Alexander, Christopher, Sara Ishikawa, and Murry Silverstein. *A Pattern Language* (New York, NY: Oxford University Press, 1977).

Amar, Akhil Reed. *America's Constitution: A Biography* (New York: Random House, 2005).

Bacon, Edmund N. *Design of Cities* (New York: Penguin Books, 1976).

Ballon, Hilary. Ed. *The Greatest Grid: The Master Plan of Manhattan 1811-2011* (New York, NY: Columbia University Press, 2012).

Bartholomew, Harland. "What is Comprehensive Zoning?," *National Conference on City Planning* (1928).

Bassett, Edward M. *The Master Pan: With a Discussion of the Theory of Community Land Planning Legislation* (New York: Russell Sage Foundation, 1938).

Bassett, Edward M. and Frank B. Williams. "The Preservation of the Integrity of the City Plan," National Municipal Review (March 1925).

Bassett, Edward M. *Recent New York Legislation for the Planning of Unbuilt Areas* (New York: Regional Plan of New York and Its Environs, 1926).

Bassett, Edward M., Frank B. Williams, Alfred Bettman, and Robert Whitten. *Model Laws for Planning Cities, Counties, and States: Including Zoning, Subdivision Regulation, and Protection of Official Map* (Cambridge, MA: Harvard University Press, 1935).

Bell, Eugenia, Ed. *49 Cities* (New York, NY: Inventory Press, 2015).

Ben-Joseph, Eran. *The Code of the City: Standards and the Hidden Language of Place Making* (Cambridge: MIT Press, 2005).

Campoli, Julie and Alex S. MacLean. *Visualizing Density* (Cambridge, Massachusetts: Lincoln Institute of Land Policy, 2007).

Carmona, Michel. *Haussmann: His Life and Times, and the Making of Modern Paris* (Chicago, IL: Ivan R. Dee, 2002).

Chase, Lester G. *Survey of City Planning and Related Laws in 1927 and 1928* (Washington: Department of Commerce, 1931?).

Le Corbusier. *The City of To-Morrow and Its Planning* (New York, NY: Dover Publications, 1987).

Daniels, Brigham. “Revitalizing Zion: Nineteenth-Century Mormonism and Today’s Urban Sprawl,” Journal of Land, Resources & Environmental Law (Forthcoming).

Davidson, Michael and Fay Dolnick, Ed. *A Planner's Dictionary* (American Planning Association, 2004).

Dennis, Michael. *Court & Garden: From the French Hôtel to the City of Modern Architecture* (Cambridge, MA: MIT Press, 1986).

Duany, Andres, Elizabeth Plater-Zyberk, and Jeff Speck. *Suburban Nation: The Rise of Sprawl and the Decline of the American Dream* (New York, NY: North Point Press, 2000).

Burnham, Daniel and Edward Bennett. *Plan of Chicago* (Chicago, IL: Commercial Club, 1909).

Etienne, Harley F. and Barbara Faga, Ed. *Planning Atlanta* (Chicago, IL: Planners Press, 2014).

Franzen, Torkel. *Godel's Theorem: An Incomplete Guide to Its Use and Abuse* (Wellesley, Massachusetts: A K Peters, 2005).

Gehl, Jan. *Cities for People* (Washington, DC: Island Press, 2010).

Ghyka, Matila. *The Geometry of Art and Life* (New York: Dover Publications, 1977).

Glaeser, Edward. *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier* (New York, NY: Pengiun Group, 2011).

Greenblatt, Stephen. *The Swerve: How the World Became Modern* (New York, NY: W.W. Norton & Company, 2011).

Haar, Charles M. "In Accordance with a Comprehensive Plan," [...] (1955).

Hardin, Garrett. "Tragedy of the Commons," *Science* (December 1968).

Hillier, Bill and Julienne Hanson. *The Social Logic of Space* (Cambridge: Cambridge University Press, 1984).

Hillier, Bill. *Space is the Machine*, electronic edition (www.spacesyntax.com: Space Syntax, 2007).

Hillier, B., A. Leaman, P. Stansall, and M. Bedford. "Space Syntax," *Environment and Planning* (August 1976).

Hofstadter, Douglas R. *Godel, Escher, Bach: an Eternal Golden Braid* (New York: Basic Books, 1990).

Hofstadter, Douglas R. *Metamagical Themas: Questing for the Essence of Mind and Pattern* (New York: Basic Books, 1985).

Holloway, Marguerite. *The Measure of Manhattan: The Tumultuous Career and Surprising Legacy of John Randel Jr.* (New York, NY: W.W. Norton & Company, 2013).

Jackson, John Brinckerhoff. *Landscape in Sight: Looking at America*, ed. Helen Lefkowitz Horowitz (New Haven: Yale University Press, 1997).

Jacobs, Allan B. *Great Streets* (Cambridge, MA: MIT Press, 1993).

Jacobs, Jane. *The Death and Life of Great American Cities* (New York: Vintage Books, 1992).

Johnson, Hildegard Binder. *Order Upon the Land: The U.S Rectangular Land Survey and the Upper Mississippi Country* (New York, NY: Oxford University Press, 1976).

Jordan, David P. *Transforming Paris: The Life and Labors of Baron Haussmann* (New York, NY: The Free Press, 1995).

Kirkland, Stephane. *Paris Reborn: Napoléon III, Baron Haussmann, and the Quest to Build a Modern City* (New York, NY: St. Martin's Press, 2013).

Knack, Ruth and Israel Stollman. "The Real Story Behind the Standard Planning and Zoning Acts of the 1920s," Land Use Law (February 1996).

Kostof, Spiro. *The City Shaped: Urban Patterns and Meanings Through History* (New York, NY: Bulfinch Press, 1991).

Linklater, Andro. *Measuring America: How the United States was Shaped by the Greatest Land Sale in History* (New York, NY: Penguin Group, 2013).

Linklater, Andro. *The Fabric of America: How Our Borders and Boundaries Shaped the Country and Forged Our National Identity* (New York, NY: Walker & Co., 2007).

Lynch, Kevin. *Good City Form* (Cambridge, MA: MIT Press, 1998).

Macey, Samuel L. *The Dynamics of Progress: Time, Method, and Measure* (Athens, GA: University of Georgia Press, 1989).

Nagel, Ernest and James R. Newman. *Godel's Proof* (New York: New York University Press, 2001).

van Nest Black, Rusell. *Building Lines and Future Streets: Their Establishment and Protection* (Cambridge: Harvard University Press, 1935).

Nichols, Philip. "Protecting the City Plan—the Next Steps," Massachusetts Federation of Planning Boards (November 1924).

Mandelker, Daniel, John Payne, Peter Salsich, Jr., and Nancy Stroud. *Planning and Control of Land Development: Cases and Materials* (Newark, NJ: LexisNexis, 2008).

Marshall, Stephen. *Streets and Patterns* (New York, NY: Spon Press, 2015).

Meltz, Robert, Dwight H. Merriam, and Richard M. Frank. *The Takings Issue* (Washington, D.C.: Island Press, 1999).

Morris, A.E.J. *History of Urban Form: Before the Industrial Revolution* (Dorchester, England: Dorset Press, 1994).

Moudon, Anne Vernez. *Built for Change: Neighborhood Architecture in San Francisco* (Cambridge, MA: Massachusetts Institute of Technology, 1986).

Plato. *Laws, Book V*.

Reps, John W. *The Making of Urban America* (Princeton, New Jersey: Princeton University Press, 1965).

Rossi, Aldo. *The Architecture of the City* (Cambridge, MA: MIT Press, 1988).

Rowe, Colin and Fred Koetter. *Collage City* (Cambridge: MIT Press, 1984).

Rudman, Peter S. *How Mathematics Happened: The First 50,000 Years* (Amherst, NY: Prometheus Books, 2007).

Siksna, Arnis. "The Effects of Block Size and Form in North American and Australian City Centres", *Urban Morphology* Vol. 1, 1997.

Speck, Jeff. *Walkable City: How Downtown Can Save America, One Step at a Time* (New York, NY: North Point Press, 2012).

Suber, Peter. *The Paradox of Self-Amendment: A Study of Logic, Law, Omnipotence, and Change* (New York, NY: Peter Lang Publishing, Inc., 1990).

Taleb, Nassim Nicholas. *Antifragile: Things That Gain from Disorder* (New York, NY: Random House, 2014).

Talen, Emily. *City Rules: How Regulations Affect Urban Form* (Washington, DC: Island Press, 2012).

Treat, Payson J. *The National Land System* (New York, NY: E.B. Treat & Company Publishers, 1910).

Unwin, Raymond. *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (New York, NY: Princeton Architectural Press, 1994).

Wilson, Thomas D. *The Oglethorpe Plan: Enlightenment Design in Savannah and Beyond* (Charlottesville, VA: University of Virginia Press, 2012).

Wolf, Michael Allan. *The Zoning of America: Euclid v. Ambler* (Lawrence, KA: University Press of Kansas, 2008).

1. This concept of life expectancy is addressed by Brenda Scheer in "The Anatomy of Sprawl", *Places* Volume 14, Issue 2.
2. There is a lot of spread in this number. The average residential building lasts about 150 years, but the average big-box or low-quality apartment complex lasts about 20 years. The overall average for all buildings is roughly 80 years.
3. "Street" is being referred to here not just as the asphalt, or the thing one drives on. Rather, the legal definition of "street" is a public right-of-way with its boundary lines that distinguish between public property and private property. The whole cross section of the right-of-way is the street: from property line to property line
4. Address before the Second National Conference on City Planning, 1910.
5. From Wagner's book *Modern Architecture*, 1902.
6. From Doug Allen's "The History of Urban Form," Lecture 01, delivered 2013.
7. In 2012, the Museum of the City of New York held an exhibit titled "The Greatest Grid" which explored the history of the city's grid plan. A book of the same name contains numerous, well-written, insightful essays on the significance of the plan and is well worthy of study.
8. Remarks of the Commissioners for Laying out Streets and Roads in the City of New York, Under the Act of April 3, 1807
9. Knack, Ruth and Israel Stollman. “The Real Story Behind the Standard Planning and Zoning Acts of the 1920s,” *Land Use Law* (February 1996).
10. For more on this history, refer to works by Ruth Knack, Michael Wolf, Jane Jacobs, and Andres Duany in the bibliography.
11. See the first sentence of the first page in *A Zoning Primer* written in 1926 as a guide to the Standard State Zoning Enabling Act written in 1922.
12. This concept is known as *induced demand*. See works by Andres Duany and Jeff Speck in the bibliography.
13. Refer to https://www.planning.org/greatplaces/ for more information on the criteria of selection
14. This likely stems from the fact that many cities built at the turn of the century incorporated small blocks, and over time development has naturally been concentrated there of decades or centuries.
15. Recall from your statistic class that relative standard deviation is a standard deviation normalized about the mean. In other words, it is a measure of variance that allows you to compare completely different things: in this case, population and block size.
16. Refer back to the discussion of number theory in the introduction.
17. Remarks of the Commissioners for Laying out Streets and Roads in the City of New York, Under the Act of April 3, 1807

18. Note that this particular analysis was done using imperial units. This will be adapted to metric in future updates to this paper.
19. A Standard City Planning Enabling Act, p. 13.
20. For the complete paper see http://www.dozenalsociety.org.uk/pdfs/aitken.pdf
21. ibid.
22. A tribal subdivision (per Merriam-Webstier.com).
23. A unit of local government in ancient Attic (per Merriam-Webstier.com).
24. https://www.dpz.com/wp-content/uploads/2017/06/Lexicon-2014.pdf